DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

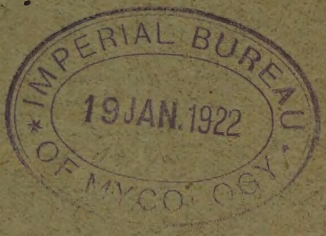
FOOD INVESTIGATION BOARD

SPECIAL REPORT NO. 6

The "Black Spot" of Chilled and Frozen Meat

BY

F. T. BROOKS, M.A. and M. N. KIDD



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DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH

FOOD INVESTIGATION BOARD

Meat Preservation Committee

Report upon the "Black Spot" of Chilled and Frozen Meat,

by

F. T. Brooks, M.A. and M. N. Kidd

Consignments of beef and mutton brought from the Argentine, New Zealand, and other countries, are sometimes found on arrival in this country to be disfigured by the presence of black spots on the surface. Such meat is liable to be condemned at the port of entry. Towards the end of the war, and for some time after the cessation of hostilities, a considerable amount of meat coming from the southern hemisphere was found to be thus affected, chiefly, as investigation subsequently showed, in consequence of the unduly prolonged periods of storage in the producing countries.

"Black spot" of chilled beef from the Argentine was examined some years ago in a preliminary manner by Massee,* who found that its appearance was due to a fungus which permeated the superficial layers of the meat, the black colour being actually due to the fungus threads.

In view of the receipt, during 1918, of several consignments of meat of various kinds coming from different countries and found to be affected by similar black spots, the Food Investigation Board decided that a detailed investigation of the occurrence and nature of "black spot" should be carried out. The present report is an account of the present state of our knowledge of the "black spot" fungus in so far as it affects meat in cold storage.

Figs. 1 and 2 show the appearance of typical "black spot" upon the surface of beef and mutton respectively. This trouble occurs also on lamb, veal, and rabbits, and, whatever the kind of meat affected, the appearance is the same. Each spot, which varies from 1 to 2 cm. in diameter, is formed by the growth of

* Massee, G. On the discoloured spots sometimes present on chilled beef, with special reference to "Black spot." *Journal of Hygiene*, Vol. XII., 1912.

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the brownish-black threads of a certain fungus in the tissues of the meat, the spots tending to become darker with age. The spots are sometimes so numerous as to overlap one another, but more frequently they remain isolated. If the spots are abundant, the meat is very unsightly, and may be considered unsaleable for the purpose of food. These spots are liable to occur on any part of the carcase, but in beef they are most frequent on the skirt and pleura, and in mutton on the legs and the interior of the thorax. Skinned rabbits are more liable to be affected than unskinned ones. "Black spot" has been found on New Zealand mutton and lamb, on Australian mutton and rabbits, and upon beef from the Argentine and from South Africa.

The same fungus has been repeatedly isolated from these sources, and it is of interest that, with an exception to be noted below, the fungus affecting cold-store meat in these countries is identical. The "black spot" fungus, when isolated and grown in pure culture, is found to be one of the many forms of the common mould (*Cladosporium herbarum*) which is of frequent occurrence on dead and moribund vegetable debris. On three occasions a somewhat different fungus has been isolated from black spots, but the differences between this and what may be called the typical fungus of "black spot" are very minute, and are only clearly discernible in artificial cultures. Such a form, in fact, is only a slightly differentiated strain of the same species.

The fungus *Cladosporium herbarum* is of world-wide occurrence upon decaying vegetable tissue, and its spores are commonly, perhaps constantly, present in the air. For instance, as the leaves of grasses and other plants begin to decay, this fungus usually begins to grow upon them, soon shedding spores into the atmosphere. Dried herbage of every description harbours these spores, which develop mould growths under moist conditions. Thus, both the herbage or fodder with which the animals are fed before slaughter, and also their excreta, serve as sources of the spores, which may contaminate the meat either just before it is placed in cold storage or while actually in store. The black spots caused by this fungus on meat rarely give rise to spores while in the cold store, but if the temperature rises above freezing point, or if the meat is removed into ordinary air, these spots form spores freely on the surface of the meat. A few examples have been seen, however, in which spores were formed on the spots during storage.

Massee stated in 1913 that the fungus grew appreciably at 0° C., and that growth below this temperature was very slow. He did not present evidence for these statements, and, perhaps on this account, there has been much scepticism as to whether the fungus did actually grow and form "black spots" on meat below the freezing point of water. The opinion has sometimes been expressed that perhaps in all cases of the development of this trouble there has been a breakdown of the refrigerating

plant, either in the cold store, before shipment, or during transit across the seas. During 1918 opportunity was given one of the writers of inspecting consignments of meat affected by "black spot" on arrival in this country, and there sometimes seemed to be good evidence that no breakdown of the machinery had occurred either in the country of origin or on the ship, even where the meat (mutton) had been frozen hard.

It was important, therefore, to determine under what conditions the "black spot" fungus would develop in cold stores. Critical experiments have been made in this connection, and, although the investigations are not yet complete, sufficient data are to hand showing conclusively that the fungus can grow and produce black spots on meat kept at a temperature which does not rise above 22° F. (− 5·5° C.) *i.e.*, several degrees below freezing point. These experiments have been conducted in a small cold store, and have extended over a considerable period. Only one chamber has been available, and as the experiments occupy much time it has not yet been possible to determine the lower limit of temperature at which the fungus will grow, but it is evident that 22° F. (− 5·5° C.) is by no means the minimum. Spores of the fungus isolated from meat have been sown in tubes of nutrient media and upon pieces of meat, which have then been placed immediately in the cold store and kept constantly at a temperature of 18°—22° F. The fungus develops more quickly on artificial media (especially upon those containing vegetable extracts) than on meat, and in the former, growth is discernible in about six weeks. As is to be expected at this low temperature, the rate of growth is very slow, but after a year large masses of the fungus are evident in the tubes. The fungus produces spores more readily on artificial media than on meat under the same conditions. It is of interest that strains of the fungus *Cladosporium herbarum*, isolated from vegetable debris, also have been found to grow slowly on nutrient media at these low temperatures. The spores of the fungus, which develop at a temperature of 22° F., whether isolated from cold-store meat or from vegetable tissue, are of the same character as those produced by the fungus at ordinary temperatures, and are of two kinds, oval spores 8—16μ × 4– 5μ which may be once septate, and roughly spherical spores 3, 5–5μ in diameter, budded off in chains from the former. The conidiophores from which the spores arise at low temperatures are more variable in their habit of branching than similar structures which develop in a normal atmosphere; conidiophores arising under cold-store conditions are sometimes entirely unbranched. "Black spots" have been produced artificially on meat in about six months under similar cold-store conditions. If, however, instead of placing the tubes and pieces of meat in the cold store immediately after inoculation, these are kept at ordinary temperature for 24—48 hours, so as to allow of the early stages in germination being effected before subjection

to a low temperature, it is found that subsequent development in the store is more rapid, and, with meat, more certain.

A continued low temperature such as the above does not seriously affect the vitality of the spores, for if these are kept for a period of six months at 18°—22° F. without germination, they develop normally when removed to an ordinary temperature.

At freezing point, the "black spot" fungus develops much more quickly, both on artificial nutrient media and upon meat, than at low temperatures, and it is clear that if a cold store or refrigerator rises to this temperature the chances of "black spot" developing will be greatly increased if spores are present. At temperatures several degrees above freezing point, bacterial growth, arising from germs which are always lurking on the surface, is so vigorous as to inhibit the growth of the "black spot" fungus to a great extent.

To sum up the relation to temperature, "black spot" can grow at temperatures above, say, 18° F. (– 7·7° C.). At the lowest temperatures growth is very slow. Above the freezing point growth under cold storage conditions is also slow, but this is due, not to the direct influence of the temperature upon the fungus, but to the fact that above the freezing point actively growing bacteria compete with the fungus, and more or less completely prevent it from developing. Therefore, because of the bacteria at the higher temperatures and the direct influence of cold at the lower temperatures, the most favourable temperatures for the appearance of "black spot" lie at, and just below, the freezing point.

It is likely, too, that considerable fluctuations of temperature in the store, even well below freezing point, will increase the danger of the development of "black spot," on account of changes in the humidity of the surface of the meat brought about by the deposition of snow, and also to the fact that, if spores are present in the air, they may fall on to the meat with the snow. For the same reason the ingress of moist air into the store from outside should be controlled.

Abrasions of the meat seem to exercise no influence on the relative development of "black spot"; in fact, the experimental evidence at present available indicates that unwounded meat surfaces are more readily attacked by this fungus than meat in which incisions have been made.

On meat, this fungus develops particularly upon the subcutaneous connective tissue whether overlying muscle or fat. The fungal threads sometimes penetrate this "skin" to the underlying tissues, especially muscle, the maximum depth to which the fungus has been seen to grow being about one-sixth of an inch (4 mm.), although it is usually considerably less. The same fungus has also been isolated from the packing material in which the meat is enclosed.

Information received points to the abnormally long periods of storage necessary during 1917–19 as being the main cause

of the comparative prevalence of "black spot" at that time. When the meat arrives here within a reasonable period after the animals are killed, as it does in normal times, the occurrence of this trouble is relatively rare. Under the normal conditions of the trade, when the meat reaches this country in good condition, it is likely that spores of the "black spot" fungus and of other mould fungi may be lurking on the surface in a dormant condition, the period of storage and the temperature not having been such as to allow of their development into unsightly growths upon the meat. If for any reason the period of storage is likely to be unduly prolonged, the temperature should be reduced accordingly, although there is no explicit information at present as to the lowest temperature at which this black mould will develop. It has occasionally happened in practice that newly-killed carcases have been placed so rapidly and in such numbers in the store as to cause the temperature of some parts of it to rise to a few degrees above freezing point. Needless to say, such an occurrence is conducive to the development of "black spot." Experience has shown also that, where carcases are piled in deep layers over one another, the lowest are especially liable to develop this trouble during long storage. The practice of cutting and telescoping mutton carcases, prevalent during the latter part of the war for economising space, also appeared to render the meat more liable to "black spot."

There is no ready means of killing spores of the "black spot" fungus which may be present in the atmosphere of a cold store, but precautions can be taken to limit their numbers and to check their germination on the meat. Since decaying fodder, animal excreta, and offal may all be sources of this fungus, stock-yards and abattoirs in the vicinity of cold stores should be kept as clean as possible. If the meat in a store happens to become contaminated, the store should be disinfected before new carcases are inserted. This is probably best done by some process of fumigation combined with washing the interior with some disinfectant such as Condy's fluid. It is undesirable to use formalin in this connection, as traces of formaldehyde which may remain in the air will enter into combination with the meat subsequently inserted.

Meat affected by "black spot" is unsightly, and is often condemned for food purposes when the fungus is present in abundance. Meat of this kind also has often deteriorated much in quality through long storage, altogether apart from any action caused by the fungus. *Cladosporium herbarum*, however, produces no toxic substances during growth, whether upon meat or on other substrata, so that the presence of the fungus alone does not render the meat dangerous or unfit for human consumption. It may be mentioned that one of the writers and a friend of his have eaten large quantities of this fungus mixed with other food without deleterious results. Spots of this character are also so superficial that only an infinitesimal amount

of the meat is really affected. During the latter part of the war much meat spotted in this manner was legitimately saved by trimming away the most conspicuously damaged parts. "Black spot" is not itself pathogenic, and its presence is not indicative of putrefactive changes; it may, however, be accompanied by putrefactive bacteria, and when this is the case it might be unwise in the present state of our knowledge to attempt to save the meat for human consumption. It should be remembered, that in all such cases, the reason for condemnation is the presence of the bacteria and not the fungus. By unthawing one or two carcases of a consignment affected by "black spot" it can readily be ascertained if putrefactive bacteria also are present. Meat affected by these bacteria is soft and smells disagreeably, but if "black spot" alone is present, the meat is firm and without offensive odour. Except for its disagreeable appearance, there seems to be no reason why meat affected only by "black spot" should be condemned for food.

Other fungi, which may or may not accompany "black spot," are sometimes found on meat which has been kept in cold storage, some of which develop with great abundance when there has been a breakdown of the refrigerating plant. Thus white moulds (species of *Sporotrichum* and *Oospora*), bluish-green moulds (*Penicillium spp.*), pink yeasts, together with the profuse growths known in the trade as "whiskers" (*Mucor spp.* and *Thamnidium spp.*) are of frequent occurrence. There is evidence that the white moulds at any rate can develop at temperatures below freezing point during prolonged storage, but subsequent reports will deal with the exact conditions under which these various forms develop upon meat.

F. T. Brooks.
M. N. Kidd.

December 1920.

FIG. 1.

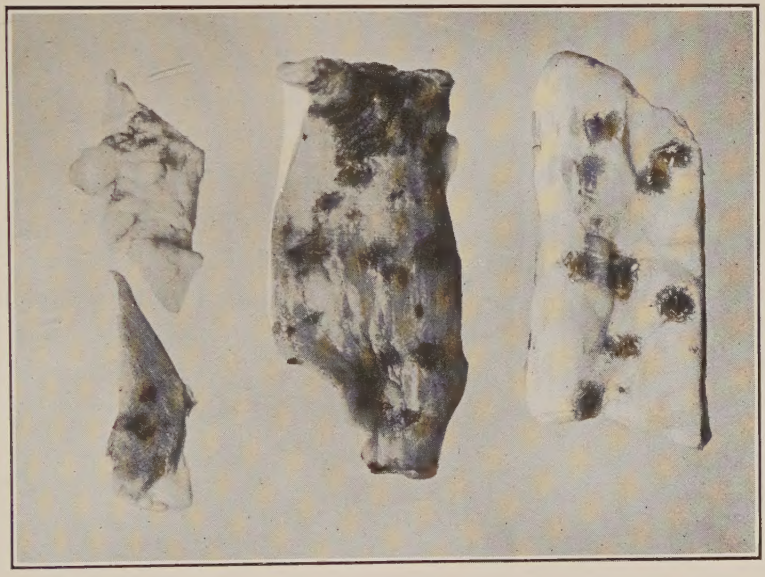

FIG. 2.

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